Mark scheme for Support Worksheet – Topic E, Worksheet 2

1 The distance in pc is given by $d = \frac{1}{0.122} = 8.197$ pc and so $d = 8.197 \times 3.26 = 27$ ly [1]

2 Apparent magnitude is a logarithmic measure of the apparent brightness of a star. [1]

3 $\frac{b_X}{b_Y} = 2.51^{m_Y - m_X}$; $\frac{b_X}{b_Y} = 2.51^{3.2-5.2} = 0.1587 \approx 0.16$ [2]

4 Absolute magnitude is a logarithmic measure of the luminosity of a star/it is the apparent magnitude the star would have from a distance of 10 pc. [1]

5 The distance magnitude relation is $m - M = -5 + 5\log_{10} d$ with the distance in pc.
Thus, $3.1 - (-1.3) = -5 + 5\log_{10} d \Rightarrow \log_{10} d = 1.88$; and so $d = 75.86 \approx 76$ pc [2]

6 From $m - M = -5 + 5\log_{10} d$ and so $12 - M = -5 + 5\log_{10} 520$; $M = 14.28 \approx 14$ [2]

7 **a** Variable stars are stars with non-constant luminosity/apparent brightness. [1]

b Cepheid stars are variable but they have a constant period of variation of luminosity which in turn is related to the average luminosity. [1]

8 The star expands and contracts periodically. [1]

9 It means stars of known luminosity; so that comparison of stars with known apparent brightness gives their luminosity. [2]

10 The Olbers paradox claims that in an infinite universe with an infinite number of stars, the brightness of the night sky would be infinite/very large; because even though a shell around the Earth far from the Earth would contain more stars than a closer shell, it would contribute the same amount of apparent brightness; because apparent brightness decreases as $\frac{1}{d^2}$ and the number of stars in the shell increases as d^2. [3]

11 In the standard Big Bang cosmology the Olbers paradox is resolved because there is a finite number of stars with a finite lifetime; some stars are so far away their light has not yet reached us. [2]

12 Redshift means that the wavelength received is longer than the wavelength emitted; according to the Doppler effect this happens when the source of the light moves away from the observer and so the distant galaxies move away from us, i.e. the universe is expanding. [2]

[This answer is based on the conventional and not entirely correct point of view based on the Doppler effect. In reality, the redshift (increased wavelength) is due to the stretching of space in between the source and the observer, which is precisely what is meant when we say that the universe expands.]

13 Cosmic background radiation is isotropic blackbody radiation; that appears to be coming from everywhere in space/does not have a specific point of origin. [2]

14 In the early universe the radiation in the universe was in equilibrium at a very high temperature; as the universe expanded the temperature fell and so the radiation we observe today is at the low temperature we measure today (2.7 K). [2]

15 The student is correct; when the Big Bang happened the universe was just a point so the Big Bang happened everywhere in the universe. [2]

16 The universe contains a lot of dark matter which does not radiate and so cannot be easily detected/it can only be detected by its gravitational effect on nearby bodies. [1]

17 Neutrinos/weakly interacting particles/brown and black dwarfs. [2]

18 Critical density is that density of the universe for which the universe will continue to expand forever with a rate that will approach zero after an infinite time. [1]

19 If the actual density of the universe is less than the critical density then the universe will expand forever; if the actual density is greater than the critical density then the universe will collapse after a period of expansion. [2]

20 The main determining factor is the mass of the star. [1]